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CONTRIBUTION TO THE STUDY OF THE PLANTAR REFLEX, BASED UPON SEVEN HUNDRED EXAMINATIONS MADE WITH SPECIAL REFERENCE TO THE BABINSKI PHENOMENON.*

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Attention was first called by Babinski, in 1896, to the fact that in pyramidal tract disease stroking the sole of the foot often produces extension of the great toe, with or without extension and separation of the other toes. The status of this phenomenon as a practical aid in diagnosis has not yet been definitely determined. The diversity of opinion is shown by the conclusions of two recent investigators; Boeri, who represents the majority, states that it occurs in at least 76 per cent. of hemiplegics, old and recent, that it is a test of special value in the comatose stage of hemiplegia, and equally useful in distinguishing organic disease from functional disorder. Cohn, on the other hand, while allowing that extension is noted more often than flexion in disorder of the lateral columns *whether organic or functional*, adds that in no way can this phenomenon have any real pathognomonic value in diagnosis.

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In the hope of adding something to the knowledge of this subject, we have investigated 200 hemiplegics and diplegics, old and new; 30 cases of spinal disease involving the pyramidal tract, 70 infants, and 400 cases in which no recognized lesion of the pyramidal tract existed, the last group including 200 cases of nervous disease both organic and functional, 100 normal individuals, and 100 cases taken at random from hospital patients outside the neurological department. This study confirms the claim that the Babinski phenomenon furnishes a most important positive sign and definite aid in diagnosis. It would seem that this plantar reflex stands for something even aside from other symptoms, a distinction which we can hardly accord even to the knee-jerk, the importance of which, when taken as a link in the chain of symptoms, is paramount. Unlike the ankle-clonus it has no spurious analogue in functional affections, it is rarely difficult to elicit when present, it appears early in the disease, when every diagnostic sign is needed, and may be present during the later stages when other reflexes have disappeared on account of ankylosis or muscular atrophy.

Previous to the contributions of Babinski little attention was paid to the plantar reflex. It was taken as a matter of routine, like other skin reflexes, and the direction of the toe movement was not especially noted; it seems doubtful, however, if its presence, absence, and degree of activity are likely to prove often of great diagnostic value, as our collection of cases illustrates, but the demonstration of the Babinski phenomenon is of prime importance.

The first communication of Babinski[1] called attention to the fact that, in pyramidal disease, stimulation of the sole of the foot provoked extension of the toes, and particularly of the great toe, the other muscular contractions (flexion of thigh on pelvis, leg on thigh, foot on leg) persisting as in health. He named this reflex *le phénomène des orteils*. Two years later[2] he called attention to certain characteristics of the reflex movement, for example, that extension is slower than flexion, and that flexion is stronger when the inner half of the sole is excited, the converse being true of extension. He cited varieties of reflex partly physiological and partly pathological, noting, for example, that sometimes stroking one part of the foot would produce flexion, another part extension, the first reaction obtained in a given case being generally flexion; again, he sometimes noted extension of the two inner, with flexion of the outer, toes in response to a single stimulation. His observations have been confirmed by Van Gehuchten,[3] Glorieux,[4] Genault,[5] Létienne and Mirouche,[6] Buzzard,[7] Kalischer,[8] Cestan and Le Sourde,[9] Collier,[10] Boeri,[11] and Brissaud,[12] and in this country by Langdon.[13]

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[1] Babinski, Compt. rend., Soc. de Biol., Par., 1896.

[2] Babinski, Semaine méd., Par., 1898, xvii, pp. 321-22.

Its practical importance is denied by Schüler,[14] and by Cohn.[15] Giudiciandrea[16] has contributed to the uncertainty by stating that he has found extension in hysteria and in normal individuals.

Collier found in infants extension the earliest response; in pyramidal tract disease he found a similar reflex to that obtaining in infants, but more deliberate, extension of the great toe preceding other movements. He regarded this reflex as one of the first signs to appear, and the last to disappear, in temporary lesions, and stated that it might be the only unequivocal objective sign of pyramidal disease. He found it was the only reflex present in total transverse lesion of the cord. He regarded tetanus and large doses of strychnine the only additional possible sources of the extensor reflex.

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[3] Van Gehuchten, Jour. de Neur., April 5, June 20, July 5, 1898.

[4] Glorieux, *idem*, Dec. 5, 1898.

[5] Genault, Th. de Paris, 1898.

[6] Létienne and Mirouche, Arch. gén. de méd., 1899, No. 2, p. 191.

[7] Buzzard, Brit. Med. Jour., 1899, No. 2001, p. 1077.

[8] Kalischer, Virch. Arch., 1899, Vol. 155.

[9] Cestan and Le Sourde (Cestan), Th. de Paris, 1899, and Arch. de méd. de Toulouse, April 5 and May 15, 1899; Bull. de la Soc. Anat., 1898 (C. & Le S. ; Gazette des hôpitaux, 1899, jeudi, 23 nos., Nr. 133, S. 1249.

[10] Collier, Brain, xxii, 71, No. 85, 1899.

[11] Boeri, Riforma medica, an. XV, vol. 11, Nos. 71, 72, 73, pp. 843, 855, 867; June 26-28, 1899.

[12] Brissaud, Gaz. hebd. de méd. Chir., Paris, 1896, xliii, 253.

[13] Langdon, Cincinnati Lancet Clinic, February 17, 1900.

[14] Schüler, Neur. Centralbl., 1899, Nr. 13, S. 585.

[15] Cohn, Neur. Centralbl., 1899, Nr. 13, S. 580.

[16] Giudiciandrea, Bull. Soc. Lancisiana, 1899, fasc. I, p. 226.

The most complete corroboration of Babinski's claim has been recently furnished by Cestan and Le Sourde, who found the extensor reflex in 92 per cent. of the 68 hemiplegics examined, and in all the 35 cases of spinal disease implicating the pyramidal tract (except one case with neuritis also), in all the 6 cases of syringomyelia, and in all the 30 cases of infantile hemiplegia and diplegia.

These observers found the extensor reflex in infants from one month to one year of age, but never found it in normal adults or in those suffering from disease other than of the pyramidal tract.

Remak[17] found the Babinski phenomenon in the same patient (suffering from lesion at about the seventh dorsal roots), who presented the so-called femoral reflex described by him in 1893. In others words, while stroking the thigh produced flexion stroking the sole produced extension of the toes.

Schüler found flexion in 80 per cent. of normal men, extension (notably of the great toe) in 8 per cent., reflex wanting in 10 per cent., indeterminate in 2 per cent. In women 80 per cent. flexion, 10 per cent. wanting, 4 per cent. extension, 6 per cent. doubtful. In infants this observer found no reflex in 40 per cent., extension in 12 per cent., flexion in 30 per cent., variable in 18 per cent. In the 8 cases of pyramidal tract disease examined (amyotrophic lateral sclerosis, combined tabes, hemiplegia and monoplegia) the extension was pronounced.

Cohn found flexion in 60 per cent. of healthy persons; extension of the great toe, with either extension or flexion of the others, in 20 per cent.; no reflex in 10 per cent.; variable movements in 10 per cent. According to this observer the reflex is generally absent in infants, but when present it usually consists in extension of the great toe. He generally found extension in cases of recent apoplexy, and found it in two cases out of four of spinal spastic disease. In one case of hysterical hemiplegia he records extension on the paralyzed side.

Schäfer[18] has recently called attention to a phenomenon in hemiplegics, which he names the antagonistic reflex, consisting in extension of the great toe produced by pinching the tendo Achillis. This reflex he finds very promptly within a day or two of the onset of hemiplegia. Since this communication Babinski has shown that pinching the skin alone over a considerable area, including that of the tendo Achillis, suffices to produce extension. We have observed the so-called antagonistic reflex frequently, but not constantly, and never in the absence of the Babinski phenomenon. This discovery, therefore, while of interest as demonstrating the variety of afferent tracts through which the Babinski reflex may be elicited, adds nothing of practical value to our knowledge, and the adoption of a special title for this method of stimulation only renders the nomenclature unnecessarily cumbersome. Schäfer's method is also objectionable on account of the painful degree of pressure usually requisite.

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[17] Remauk, Neur. Centralbl., 1 January, 1900.

[18] Schäfer, Neur. Centralbl., Nov. 1899.

The object of our communication being rather to record clinical facts than to participate in pathological discussion, no reference is made to the anatomy or physiology of the reflex. We have also limited our observations in these records, though not in our practice, to the one set of muscles under discussion, namely, those moving the toes.

We shall first take up the reflex in normal individuals and those in which pyramidal disease was absent, we shall next consider the reflex in infants, and lastly that in pyramidal tract disease, cerebral and spinal.

The most satisfactory instrument in our experience for testing the plantar reflex is the orange stick not too sharply pointed. A deliberate and even stroke is made from the heel toward the toes, the outer and middle areas being specially tested to stimulate the reflex in the great toe. It is sometimes found in susceptible individuals that accompanying the point of the stick with the finger tip affords a better control and more uniform application, and in such individuals a slight stroke at the beginning is preferable, to avoid the semi-voluntary movement which masks the true reflex. We cannot help suspecting that this semi-voluntary movement, which may be either downwards or upwards, has been mistaken for the true reflex, in some instances at least, by those observers who have noted extension in normal individuals. The true extensor reflex under consideration consists of a *deliberate, marked, extension of the great toe,* with or without extension and separation of the other toes. In some cases this movement is constant and uniform, however many times the sole is stroked; in other cases the reflex may tire, but whether persistent or non-persistent it is not to be mistaken for the variable and inconsequent movements sometimes observed in sensitive persons. *Such a reflex we have never found in normal individuals.*

The normal plantar reflex.—Opportunity to study the normal reflex under the most favorable conditions was kindly furnished us by Miss A. M. Homans, Director of the Boston Normal School of Gymnastics. Two classes, mainly young women, 20 to 25 years of age, were examined; 27 were examined in one class before gymnasium work, and 28 in the other after an hour's continuous exercise.

The results in the two groups were so similar as to lead to the conclusion that moderate fatigue has no effect on this reflex. In 40 (20 in each class) of the 55 cases the typical normal reflex was present, namely, flexion of all or some toes, generally the outer, the others remaining quiet.[19]

In 5 cases out of the 55 (slightly under 10 per cent.) no movement was elicited, this group comprised 3 from one class and 2 from the other.

The instructive group in which a typical normal reflex (flexion of all or of some toes) was present in one foot while no response occurred in the other contained 10 cases, *i. e.*, almost 20 per cent. Of these cases 5 were found in the class examined before, and 5 in the class examined after exercise.

Other normal individuals were tested to bring the number to 100. Both sexes and all ages over two years were included.

The percentages were as follows: All, or some, toes (generally outer) of both feet flexed, 75 per cent.; no movement, 10 per cent.; flexion on one side, no movement on the other, 15 per cent.

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[19] In this group, as a rule, the two sides correspond; for instance, in one case the outer three toes only of both feet were flexed, in another individual the reflex was limited in both feet to the great and second toes.

A second series of 100 cases, taken at random from the hospital, with other than nervous disease, gave approximately the same result, differing only in that fewer cases showed absence of reflex on one side and persistence on the other. These percentages were as follows: Flexion of all or some toes (generally outer) on both sides, 87 per cent.; absence of movement, 9 per cent.; flexion on one side and absence of movement on the other, 4 per cent.

The conclusion to be drawn from these cases is that the usual normal reflex consists of flexion of all or some (generally outer) toes on both feet—that in perhaps 10 per cent. of cases no movement occurs, and that in at least this proportion flexion occurs on one side and no movement on the other.

The fact that the plantar reflex is wanting in an appreciable percentage of normal individuals has been already noted by various observers; such absence has probably rarely led to a mistake in diagnosis among those at all familiar with nervous disease. It has not been, we believe, hitherto recorded, though doubtless often observed, that the reflex is not infrequently in health present on one side and absent on the other, and we feel sure that experienced clinicians have mistaken such a difference for indication of disease.

To determine the *plantar reflex in disturbance of the nervous system with no demonstrable lesion of the pyramidal tract*, 200 cases were examined, this list including such diseases, organic and functional, of the nervous system as were found in the neurological clinic at the Massachusetts General Hospital or in outside practice. These diseases included atheroma, alcoholism, acromegaly, bulbar paralysis, basal disease, concussion, cerebro-spinal meningitis, chorea, dementia, epilepsy, general paralysis, Huntington's chorea, hemorrhage in cord (lumbar), hemiplegia with recovery, head injury, hypochondria, hysteria, joint atrophy, monoplegia, paresthetic meralgia, melancholia, neuritis, neurasthenia, progressive muscular atrophy, post-diphtheritic paralysis, poliomyelitis, paralysis agitans, retarded development, Raynaud's disease, rachitis, sensory hemiplegia, senility, sciatica, specific disease of cord, tabes, tumor of the brain, and uremia.

In 65½ per cent. of these cases flexion of all or some (generally outer) toes occurred, in 16½ per cent. there was absence of movement on both sides, in 9 per cent. flexion occurred in one foot, no movement in the other; in 7 per cent. quick and variable movements appeared. The Babinski phenomenon occurred in 5 cases (2 per cent.). In these 5 cases (general paralysis, meningitis, hydrocephalus, uremia, alcoholism) implication of the pyramidal tract could not be excluded, and in view of previous study the suggestion naturally presents itself that this very sign may establish its existence. Further reference will be made to these cases.

Comparison of these percentages with those in normal individuals shows a striking similarity, and demonstrates the persistence of the normal reflex in disease.

It is of interest to note in passing that in 7 of the 18 epileptics included in this group the reflex was absent in one or both feet, that of the 15 tabetics 5, and of the 16 cases of hysteria 10, showed a like absence of reflex. This percentage of absence is far beyond the normal, though the cases are too few to add materially to statistics bearing upon these conditions.

Leaving these 49 cases out of consideration then, we had left 151 cases of various diseases of the nervous system with no more than the normal percentage of absent plantar reflex.

Opportunity to study the *infantile plantar reflex* was kindly furnished us by Dr. W. L. Richardson, and by Dr. Higgins, at Boston Lying-in Hospital, and by Drs. Morse and Bartol at the West End Nursery.

Our results coincide here rather with the observations of Cohn and Schüler than with those of Collier. In the first place we find it extremely difficult, and often impossible, to determine the nature, or even the existence, as regards the toes, of a definite plantar reflex in early infancy. In young infants automatic movements of the toes are almost constant, varying from extreme extension and separation to the opposite position, whether the sole is stroked or not; even after allowing for this source of error the results are baffling, as was illustrated by an experiment of Dr. Richardson.

After we had examined a number of infants with varying results, he announced that the last case on the list had been twice tested, having been replaced in the line by the nurse at his suggestion. Comparison of the results showed that whereas in the second test the observation was "toes generally up," the note in the first was "toes generally down." Four other infants were then tested, each twice, without the examiner knowing the order of arrangement; in only two of these four cases were the second observations like the first. In marked contrast to these results dorsi-flexion of the *foot* was constant. Over forty infants were tested, varying from a few hours to two weeks old, with similar results, the upward movement perhaps predominating, but not with sufficient constancy to establish a rule. In our opinion, therefore, the Babinski phenomenon is not constant in early infancy; in fact, we question the existence of a characteristic toe reflex at this period.

It would appear that before the pyramidal tract is developed the reflex movements of the toes, if indeed such variable movements deserve the name reflex, are merely the generalized motions characteristic of early infancy, responsive, probably, to afferent impulses, but in no way to be compared either to the normal plantar reflex or to the Babinski phenomenon.

At just what age the reflex is established we are uncertain, but our study of thirty older infants tends to show that it is not developed until after the first year. This point deserves further study.

We come now to the consideration of the *plantar reflex in pyramidal tract disease.* The opportunity to study the most interesting and instructive series of cases we have to communicate was furnished us through the courtesy of Dr. Fernald, Superintendent of the Massachusetts School for Feeble Minded. This series comprised 33 cases, of which 24 were diplegic and 9 hemiplegic.

Of the 9 hemiplegics, in two cases extension of all toes occurred on the paralyzed side with normal flexion on the other side; in two cases extension of the great toe occurred on the paralyzed side, while on the healthy side flexion obtained in one of these cases, no movement in the other; in the fifth and sixth cases marked extension occurred on the paralyzed, with slight extension on the healthy side; in a seventh case (a patient 21 years of age, hemiplegic since birth) the plantar reflex was wanting on the paralyzed side, flexion occurring on the other; in an eighth case (a woman 45 years of age, hemiplegic since birth) the reflex was wanting on the paralyzed side, slight extension occurring on the other; in the ninth case typical extension was exhibited on both sides.

The most striking exhibit was that of the diplegics. Of the 24 cases, in 15 the typical extensor reflex obtained in both feet; in 2 cases the great toe was extended, the others making no movement; in 1 case all toes were extended and separated in one foot, in the other foot separated without extension; in 1 case extension of all toes occurred on one side, no reflex on the other; in one case extension of all toes occurred on one side, while on the other side extension of the great toe only was present, the others being flexed; in 3 cases (aged 12, 17, and 24 years respectively) plantar reflex was absent as regarded the toes, though dorsal flexion of the tarsus was present; in one case it was impossible to take the reflex on account of violent choreic movements.

We would call attention to one or two points of interest in certain of the cases above summarized; in one of the 15 cases with typical extensor reflex stroking of the right foot produced a reflex on both sides (crossed reflex); in 2 of these same 15 cases the feet were in a state of contracture with marked extension of all toes, the great toe especially being in a state of hyperextension. These were both old cases, one 25 and the other 45 years of age, both paralyzed since birth; stroking the sole in one of these cases produced a very slight increase in the extension; in the other, on overcoming the extension by gentle pressure of the hand, stroking the sole brought the toe forcibly up against the hand. In the three cases with absence of movement there was extreme rigidity. In connection with these three cases it is interesting to note that in two hemiplegics reflex movement was wanting on the paralyzed side also. In these cases the paralysis was of long standing (21 and 45 years) and rigidity was marked. It is not at all impossible therefore that early in life extension was present on the paralyzed side.

In this series no case of pyramidal tract disease showed flexion of all toes of both feet. Extension in more or less complete form was present except in an occasional case in which no movement of the toes occurred. These results certainly go far toward establishing the fact that extensor reflex, when present, is pathognomonic of pyramidal disease; that absence of movement, especially in old cases, does not preclude such disease, while flexion of the toes is strongly indicative of pyramidal tract integrity.

It is of interest in this connection to observe the variation in knee-jerk and ankle-clonus as contrasted with the constancy of the plantar reflex, for while the knee-jerk was exaggerated in many cases, it was, in a considerable number, absent on one side or both, ankylosis of the knee-joint and muscular atrophy being present; ankle-clonus was generally wanting, the tarsus having become rigid.

Another interesting group of cases, at the Long Island Hospital, was furnished us through the kindness of Dr. Taylor, the visiting physician. In this group were 13 hemiplegics and 2 spinal cases. The duration of paralysis ranged from 3 weeks to 23 years, the ages from 26 to 78 years.

In the 13 hemiplegics extension of all toes on the paralyzed side with flexion or indeterminate action on the healthy side, occurred in 5; extension of the great toe on the paralyzed side with flexion or absence on the healthy side, in 3; extension of the great toe on the paralyzed side and the same in less degree on the healthy side, in 3; slight downward movement of all toes on both sides in 2 (6 months' and 4 months' standing).

In one of the spinal cases in which the great toe on the paralyzed side was extended the others were flexed when the inner, and extended when the outer, half of the sole was stroked. In the other, a congenital case of 23 years, with typical contracture and absence of knee-jerk, when the outer edge of the sole was stroked on the paralyzed side all toes were deliberately extended and separated, but when the inner side was stroked the opposite movement took place. This phenomenon was constant. On the healthy side all the toes were flexed, the great toe either extending slightly or remaining immobile.

A third group of hemiplegics was studied at the Tewksbury State Almshouse Hospital through the courtesy of Dr. Nichols. This group comprised 35 cases, varying in age from 24 to 80 years, in duration from one week to 15 years. In some cases the motion of the affected members had been practically restored.

Extension of all toes on the paralyzed side with extension or flexion of some or all on the healthy side was observed in eight cases; extension of the great toe on the paralyzed side, with flexion or absence of movement on the healthy side, existed in ten cases; extension of the great toe on the paralyzed, and the same in less degree on the healthy side, existed in six cases (in the last two classes the second was extended with the great toe in a large proportion of the cases, the outer toes being more often flexed).

The following variations of plantar reflex were noted in individual cases: no response on the paralyzed side, but flexion on the healthy side; straightening of outer toes with flexion and then extension of great toe on the paralyzed, with flexion on the healthy side; four outer flexed, great toe motionless on both sides; great toe stationary and others slightly extended on the paralyzed side, with great and second on the healthy side flexed and others immobile; great and second toes stationary, others straightening on the paralvzed side. Three cases only (1, 2, and 8 years' duration) exhibited flexion of all toes of both feet.

The preceding groups of cases are mentioned in detail as presenting fairly characteristic variations of plantar reflex in disease of the pyramidal tract.

We have examined in addition a sufficient number of hemiplegics and diplegics to bring the number to 200. In making this collection we have availed ourselves of the courtesy of the following superintendents of hospitals for the insane: Dr. Harrington, Danvers; Dr. Brown, Taunton; Dr. French, Medfield; Dr. Drew, Bridgewater; Dr. Quimby, Worcester; Dr. Page, Middletown, Conn.; and Dr. Flood, Hospital for Epileptics, Munson. We have also examined cases kindly placed at our disposal by the visiting physicians of the Massachusetts General Hospital and the Boston City Hospital, besides recording all cases coming under our own observation in the Neurological Department of the Massachusetts General Hospital and in outside practice. We have also to thank Dr. Courtney for the privilege of examining cases at the Boston Home for Incurables, and Dr. Thayer of West Newton for furnishing material from his practice.

Out of the 200 cases examined, 140 (70 per cent.) showed the Babinski phenomenon. The varieties of response in both the Babinski and non-Babinski cases were practically identical with those enumerated in the three groups detailed above.

The Babinski phenomenon in spinal disease involving the pyramidal tract.—We have examined 30 patients of this class with the following result: In lateral sclerosis we found 2 cases with the Babinski phenomenon out of 4; in syringomyelia, 1 out of 2; in ataxic paraplegia, 2 out of 5; in combined system disease, 2 out of 3; in myelitis, 5 out of 6; in trauma, 3 out of 6. In 2 cases of spinal spastic paralysis of unknown pathology, and in 1 case of hemorrhage into the cervical cord, the Babinski phenomenon was present; in 1 case of disseminated sclerosis, involving the pyramidal tract, it was absent.

The Babinski phenomenon obtained, therefore, in 60 per cent. of these cases.

The persistence of the Babinski reflex at various periods and under varying conditions was illustrated by the fact that clonus was absent at the time of our examination in 40 of the cerebral cases, and in 7 of the spinal (18) cases, showing the Babinski phenomenon. The exaggerated knee-jerk was more constant than the clonus; still, even this sign failed in 17 of the cerebral and in 5 of the spinal cases. These facts serve to emphasize the value of the Babinski sign as a practical aid in diagnosis.

Rare cases showing the Babinski phenomenon, but with no demonstrable lesion of the pyramidal tract.—The foregoing tabulation of cases would indicate that the absence of the Babinski phenomenon does not throw out pyramidal disease, but that its presence establishes this lesion with almost absolute certainty. We could say with *absolute certainty* were it not for an occasional baffling case in which extension occurs without recognizable lesion of the pyramidal tract. In our investigation five such cases have come to light, and Dr. Vickery has given us the record, in addition, of its discovery in a case of profound opium poisoning.

The first case was that of a child of 3 years, with meningitis, under the care of Dr. Vickery. The principal symptoms were unconsciousness, strabismus, opisthotonos, restlessness and convulsions. There was no König symptom. The knee-jerk was rather active. The plantar reflex consisted of decided extension of both great toes with flexion of the other toes on both feet.

The second case was that of a boy two years of age, a patient of Dr. F. L. Jack's, at the Eye and Ear Infirmary. This was a rachitic, hydrocephalic, poorly nourished infant with large abdomen, and pronounced rosary. There was a slight knee-jerk. Stroking the sole produced strong extension of all toes on both feet.

The third case was that of a general paralytic, a man 49 years old, with general weakness, but no definite hemiplegia. The knee-jerk was normal; the plantar reflex consisted of decided extension of the great toe on the right, the others spreading slightly; the great toe of the left foot straightened, but was not extended, the others having been slightly flexed.

The fourth case was that of an alcoholic patient with loss of consciousness lasting 24 hours, during which time a marked Babinski phenomenon was present and constant on both sides. (This case is mentioned in more detail further on.)

The fifth case was one of acute uremic poisoning in the service of Dr. Cutler at the Massachusetts General Hospital. The patient, a man of 60, was brought in unconscious, with exaggerated knee-jerks, ankle-clonus, and marked Babinski phenomenon on both sides. A series of convulsions ensued during which the plantar reflex disappeared entirely, to be replaced by the Babinski phenomenon in the intervals. The following day the patient was conscious, complaining only of malaise and moderate headache. The knee-jerks were not exaggerated, there was no trace of clonus, and the plantar reflex consisted of prompt flexion of all toes.[20]

It will be noted that even in these cases there was reason strongly to suspect damage to the pyramidal tract, direct or indirect, as by edema, and it seems not improbable that more complete knowledge may lead us to make such a diagnosis from this sign alone; but to draw this conclusion now would perhaps be going too far.

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[20] The disappearance of the Babinski phenomenon *during* convulsions has been noted by Keniston, as well as its appearance.

In illustration of the *aid furnished in diagnosis by this phenomenon*, we cite the following cases selected to demonstrate its significance in both cerebral and spinal lesions:

The first two cases (both middle-aged men) presented, on the initial visit, great clinical similarity, namely, headache, malaise, confusion of ideas, mental apathy preceded by restlessness, slow pulse, slight rise in temperature, and moderate aphasia without paralysis. The tendon reflexes were in neither case remarkable. The plantar reflex in one case was normal, while in the other the Babinski phenomenon was noted in the right foot. Both cases died within the week, in the first case without paralysis, in the second case with marked right-sided hemiplegia. Autopsy in the first case demonstrated internal hydrocephalus; no autopsy was obtained in the second, but the sequence of symptoms (complete right-sided hemiplegia preceded by a convulsion) established pyramidal tract disease, probably hemorrhage.

Two spinal cases, in which the Babinski phenomenon aided greatly in diagnosis, showed identical symptoms and probably resulted from identical lesions. Both these patients were women over 50 years of age, anemic, and so markedly neurasthenic that for some time organic disease was unsuspected. At the time they came under observation they were confined to bed with relaxed paralysis and incontinence of urine and feces; muscle sense was lost in the feet, and there were areas of dissociation on the lower extremities, but no marked loss of tactile sense. The knee-jerks were wanting in one case and were much diminished in the other. The Babinski phenomenon was present in both cases, and helped confirm the diagnosis, namely, Putnam's combined system disease in its terminal stage of general softening. It is not improbable that the Babinski phenomenon was present early in the course of these cases, in which event it would have established the diagnosis of organic disease at a time when all other evidence pointed in the opposite direction. It would seem, then, that this sign may not only aid in early diagnosis of organic lesion, but by its persistence in advanced amyotrophic poliomyelitis, combined system disease, and similar conditions, establish the pathology of which every other definite evidence has disappeared through involvement of the lower neurons in the destructive process.

An excellent illustration of the *permanence of the Babinski sign* through the various stages of pyramidal disease was furnished by a case of traumatic hemiplegia in the service of Dr. Beach at the Massachusetts General Hospital. The skull had been crushed by a falling derrick. Dr. Scudder removed a large plate of bone over the motor area on the right side, together with considerable lacerated brain tissue. Hemiplegia was present from the first, with relaxed paralysis and absence of knee-jerk in the earlier stages, replaced gradually by spastic condition. When first seen by us, shortly after operation, the Babinski sign was already present, though the knee-jerk was absent. When seen at the end of several months, after establishment of exaggerated knee-jerk and clonus, the Babinski sign was found to have retained unchanged its original character, namely, deliberate extension of the toes on the paralyzed side, most marked in the great toe.

The early establishment of this sign was shown by a case seen with Dr. Baxter, of Hyde Park. Crossed right hemiplegia appeared in the early morning, and when the patient was visited at 10 o'clock the Babinski sign was already established. Again, in a case in Dr. Cutler's service, the Babinski phenomenon was marked five hours after the apoplectic shock.

That the early appearance of this symptom is not invariable is shown by the following case seen in consultation with Drs. Beach and Mumford:

This was the case of a man of 60 presenting a typical history of hemorrhage from one of the perforating branches of the posterior cerebral artery, probably the external optic. The order of symptoms was right hemianopsia, numbness of the right side, restlessness, depression, followed gradually by elevation of temperature, deepening stupor, and right-sided motor hemiplegia. Death took place two weeks from the date of onset. During the first two days the plantar reflex was absent on the right side, normal flexion occurring on the left. The onset of motor paralysis was accompanied by deliberate straightening of the outer toes on the right, the great toe giving no response; this reflex remained unchanged till the day of his death. While this case may be regarded perhaps as showing an approach to the Babinski phenomenon, it cannot be cited as a typical case, but offers rather an exception to the rule, provided there was a destructive lesion of the anterior capsule. Unfortunately no autopsy was made.

The suggestion naturally presents itself that the motor paralysis was due to pressure upon, rather than invasion of, the anterior portion of the internal capsule. Whether this distinction has a bearing on the nature of the plantar reflex we are not yet in position to determine.

The following acute case (already alluded to under alcoholism) shows the importance of examining for *the Babinski sign in the unconscious state*, in which it seems likely to prove of the greatest value in diagnosis, though our material is still too scant to permit the formulation of absolute rules.

The history of this case was as follows: W. M., a pronounced alcoholic, was drawing a loaded truck down an inclined plane, when he was thrown forward, the truck striking him and fracturing his right thigh. There was no loss of consciousness. He was admitted to the Massachusetts General Hospital in the service of Dr. Homans, and was doing well up to the afternoon of the third day, when he gradually became unconscious, the temperature rising to 102 degrees. There were no local spasms, and there was no restlessness. When seen in consultation with Dr. Homans the patient was completely unconscious, the pupils contracted and irresponsive to light. There was no strabismus. The extremities, though generally quiet, were moved occasionally—that is, there was no hemiplegia. The patient gesticulated at times with his left hand as if in delirium. Both arms at times offered resistance to passive motion, though they were generally lax. The knee-jerk was absent on the left; it could not be tested on the right on account of the fracture apparatus. *The Babinski reflex in* *marked degree was present in both feet.* The next day consciousness had returned, there was paresis of the left external rectus, the left pupil was slightly larger than the right, both reacting to light. Movements were present, though sluggish on both sides. *The knee-jerk had returned and the Babinski sign had disappeared,* all toes being flexed on the right, and on the left all but the great toe, which showed no movement.

The next day the patient became restless, and on the following day was violent. On February 12 the pulse became weak and rapid, the temperature and respiration steadily rose, coma supervened, and death took place at 9.30 P. M., the temperature having reached 108.5 degrees. No paralysis appeared during this time.

Autopsy was not allowed, so that we are in doubt as to the exact pathology. This was peculiarly unfortunate, as the case seemed likely to add materially to our knowledge of the diagnostic value of this reflex. The bilateral appearance of the phenomenon without paralysis, and its disappearance in one day, certainly shows that serious lesion of the pyramidal tract was not present. The case tends to controvert the theory towards which our observations were tending, namely, that mere pressure, whether cortical or capsular, is unable to produce the Babinski reflex. The probable diagnosis in this case was alcoholism with bilateral cerebral edema, possibly accompanied by hemorrhage, but not by definite lesion of the pyramidal tract.

There is perhaps some analogy between the cerebral conditions in this case and those present during, and immediately succeeding, certain epileptic convulsions exhibiting the Babinski phenomenon. Recent observations on this point have been made but not yet published by Dr. Keniston, of Middletown.

That deep narcosis, as such, does not, necessarily at least, produce the Babinski phenomenon, is shown by the fact that we have invariably found *absence* of plantar reflex in patients completely etherized.

Conclusions.

1. In health either of the following conditions may appear

on taking the plantar reflex: (a) flexion of all toes; (b) flexion of some (generally outer) toes; (c) flexion of all toes on one side, and of some (generally outer) on the other; (d) entire absence of movement on both sides (about 10 per cent.); (e) flexion of all or of some (generally outer) toes on one side, with absence of movement on the other (at least 10 per cent.); (f) occasionally (in sensitive individuals) quick, semi-voluntary, indeterminate, movements, sometimes of flexion, sometimes of extension.

2. In early infancy no constant or characteristic movement of the toes appears, though extension is rather more frequent than flexion.

3. The Babinski reflex obtains in about 70 per cent. of hemiplegics and diplegics, and in approximately the same percentage of cases with disease involving the pyramidal tract in the spinal cord.

4. The Babinski reflex (*deliberate* and *constant* extension of the great toe, with or without extension and separation of other toes) is never present in health, and our observations lead us to doubt its existence in either functional or organic nervous or other disease not implicating the pyramidal tract.

5. This reflex is often the earliest to appear in pyramidal tract disease, *e. g.*, at the onset of a hemiplegic attack before the establishment of the exaggerated knee-jerk and ankle-clonus; it may persist during a period when other reflexes are absent, *e. g.*, when knee-jerk and ankle-clonus are wanting on account of ankylosis, contracture and muscular wasting, as in long standing diplegia, or of degenerative sequences as in combined system disease. This reflex furnishes, therefore, a most important practical aid in diagnosis.

6. This reflex very exceptionally appears in cases not conforming to recognized types of pyramidal disease (meningitis, hydrocephalus, poisoning, as by alcohol or uremia). These instances are too few materially to impair the diagnostic value of the phenomenon; in fact, the Babinski reflex alone should here rather lead us to suspect pyramidal involvement as by edema or indirect pressure.